Space Weather Technical Forecast

Issued on Thursday, 23 February 2023 at 00:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares (R1-R2/Minor-Moderate radio blackouts) likely throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate, with two low level M-flares in the last 24 hours, both from AR3234. There are now four numbered sunspot regions on the visible disc. AR3234 in the northeast is the largest region, and it maintains a beta-gamma magnetic configuration. AR3229 in the north centre disk is also of note as this was the source of the X-flare on the 17th, but has faded since then although it has a very weak beta-gamma configuration. The final sunspot worthy of comment is AR3230 in the southeast, this region has potential for a possible delta spot in its trailing portion, but this is starting to split apart. The other spot is small and simple.
Currently no significant Earth-directed CMEs are forecast, although glancing impacts may occur on Thursday and Saturday.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR at L1, were indicative of some lingering CME influence but also a High Speed Stream (HSS) from CH77. The wind speed has been slowly increasing, varying between 400-500 km/s. The density, initially average, rose to above average from 22/1330 UTC. The IMF has been at mostly Moderate levels, peaking at 12nT. The north-south component, Bz, has varied mainly weakly, but occasionally reaching moderate levels between +9/-10nT. The phi angle was mainly away from the Sun (positive), with some variation. Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2MeV) at GOES16 was at mostly background levels. The associated 24-hour electron fluence has been well below the Active (1e8 integrated pfu) threshold, reaching 3.56e6 integrated pfu at 23/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate solar activity is likely to continue, with a slight chance of High activity. The most likely regions to flare are AR3234, AR3230 and AR3229 which should all be present throughout the coming four days.

Solar Wind / Geomagnetic Activity: There are two low confidence CMEs in the forecast - one which may give a glancing blow early Day 1 (23 Feb). A second glancing blow from a CME is possible on Day 3 (25 Feb), but most of this should pass above Earth. Otherwise, Earth is experiencing a HSS from CH77/+, but this is likely to have only minor impacts and should gradually wane through Day 1. A further coronal hole, CH78/-, may give Earth a HSS during Day 3 with winds perhaps reaching elevated levels. The arrival time is low confidence. This being a negative polarity coronal hole, it is more favoured for a geomagnetic response now we are approaching the March equinox.

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Geomagnetic activity is expected to be mostly Quiet to Unsettled, but Active intervals with a slight chance of a G1/Minor Storm are possible early on Day 1 with any CME arrival, also from late Day 2 through to Day 4 with a combination of HSS and possible CME glancing blows.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is most likely to remain at Background levels, but with a slowly increasing Slight Chance of rising towards the S1 level, perhaps exceeding it, should any larger flares occur. High energy (greater than 2 MeV) electron flux may increase later in the forecast period, however this is low confidence. The associated 24-hour fluence is expected to remain below the Active threshold (1e8 integrated pfu), perhaps rising on Day 4 (26 Feb).

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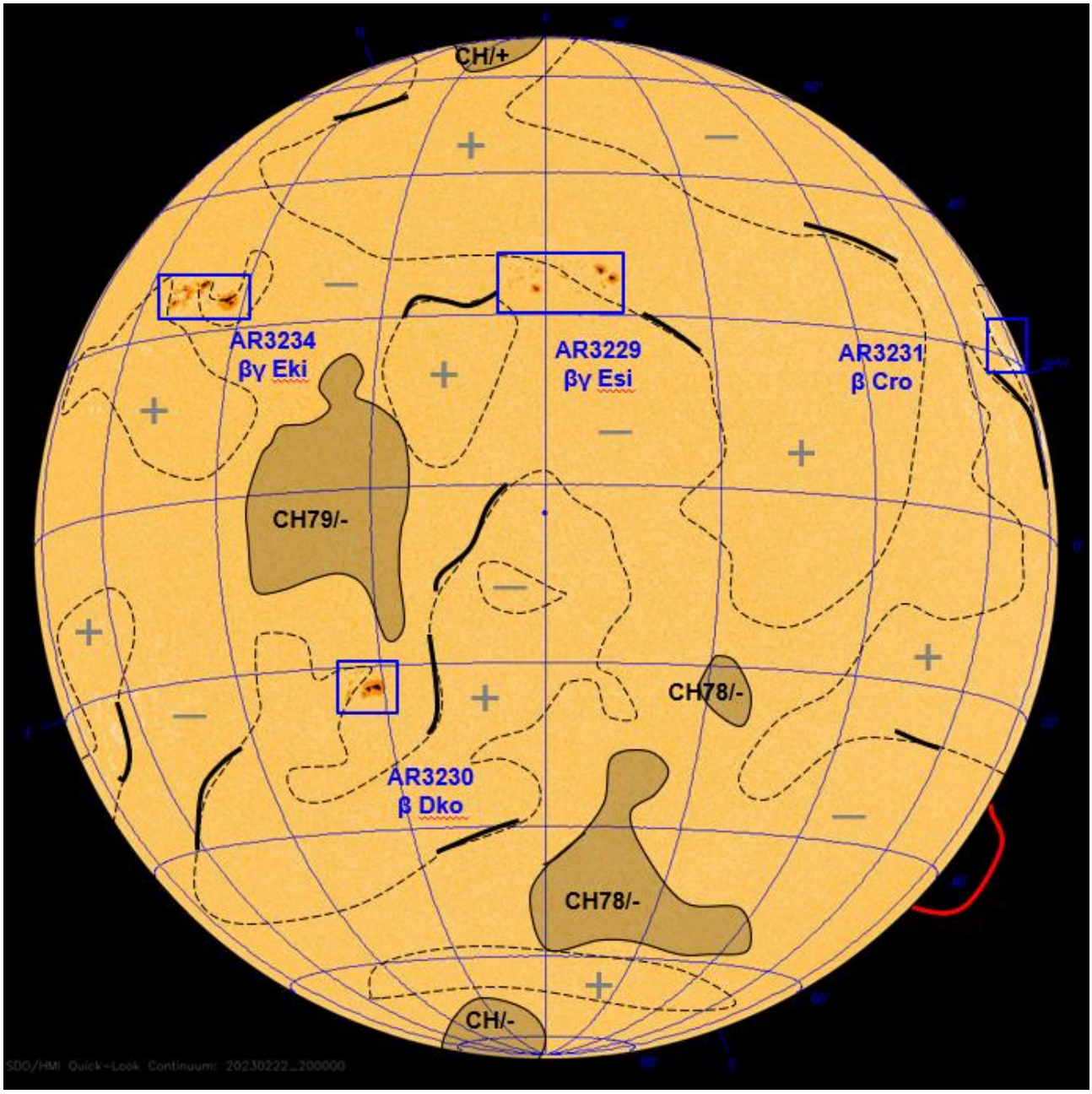
Figure 1. Solar Analysis Valid 22/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two low confidence CMEs in the forecast - one which left the southwest quadrant as a prominence eruption on 19 February, although any influence should be from the shock only and even this is low confidence. This may give a glancing blow early on Day 1 (23 Feb). A second glancing blow from a CME is possible on Day 3 (25 Feb), from a CME that left the Sun from the northwest on 21 February, but most of this should pass above Earth.

Otherwise, Earth is experiencing a HSS from CH77/+, but this is likely to have only minor impacts and should gradually wane through Day 1. A further coronal hole, CH78/-, is located well south on the visible disc but may give Earth a HSS during Day 3 with winds perhaps reaching elevated levels. This is a non-persistent feature so no information is available from the previous rotation, and the timing is therefore low confidence with the arrival possible between late Day 2 to early Day 4. This being a negative polarity coronal hole, it is more favoured for a geomagnetic response now we are approaching the March equinox.

Geomagnetic activity is expected to be mostly Quiet to Unsettled, but Active intervals with a slight chance of G1/Minor Storm are possible early on Day 1 with any CME arrival, also from late Day 2 through to Day 4 with a combination of HSS and possible CME glancing blows.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	5	20	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
*	*	*	*	*	*	*

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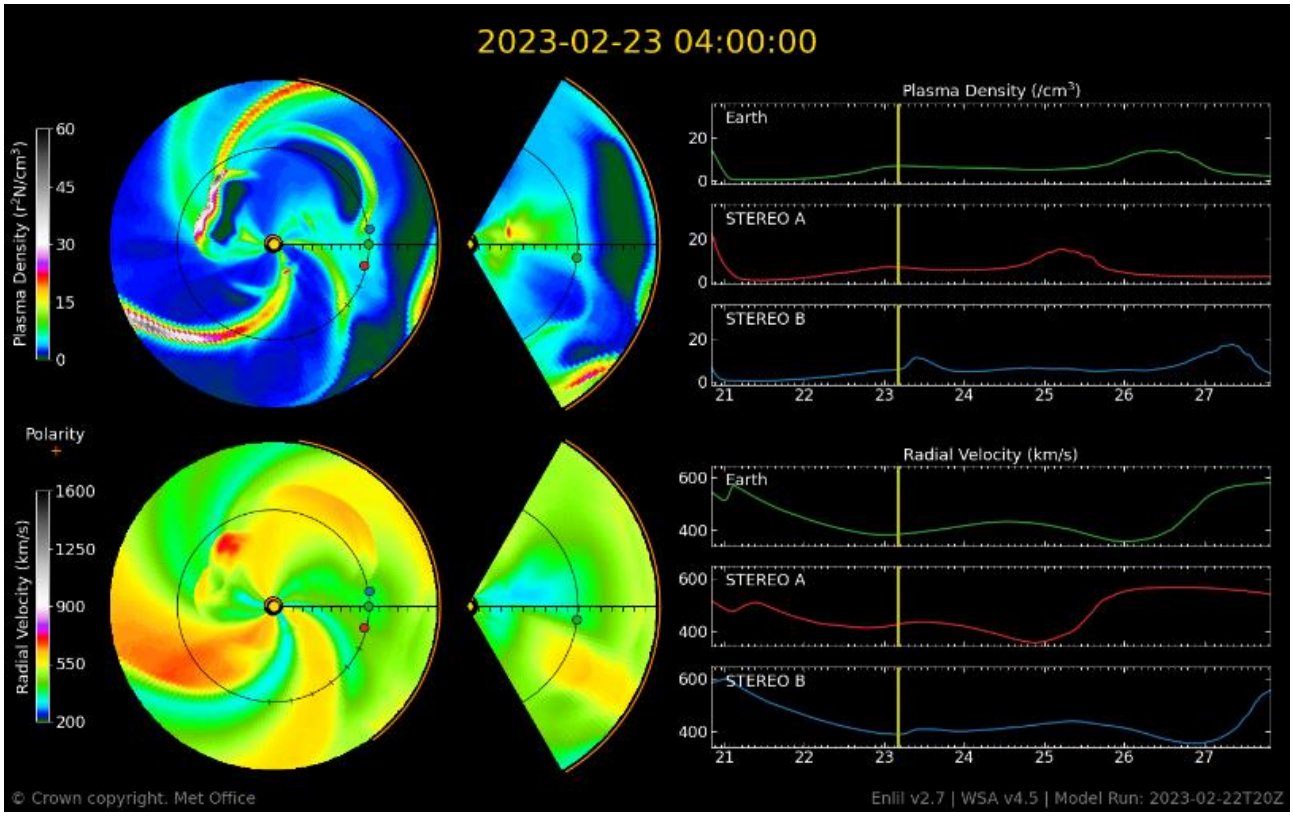
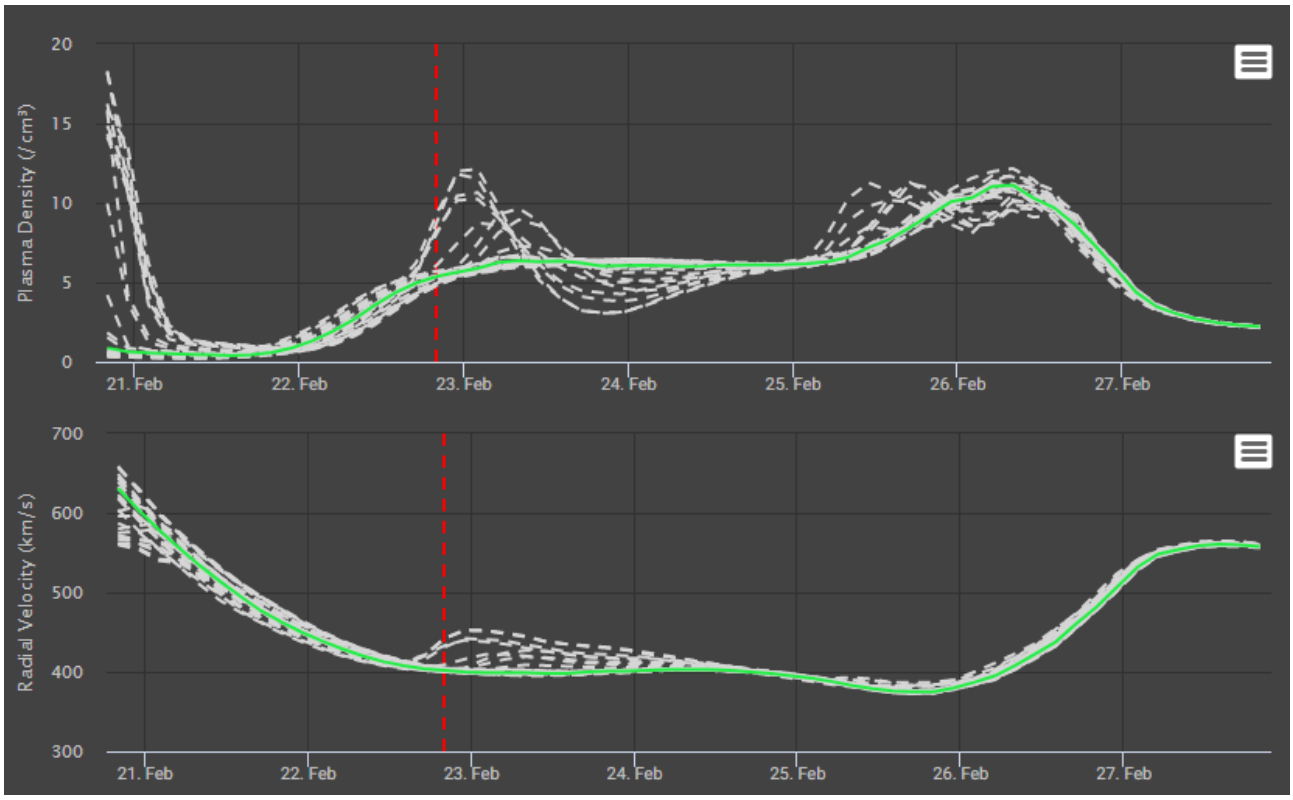
Figure 2: MOSWOC Enlil and ensemble, showing a risk of CME glancing blows, plus a minor fast wind on 24th Feb. This may be a little faster and possibly later than suggested by Enlil.





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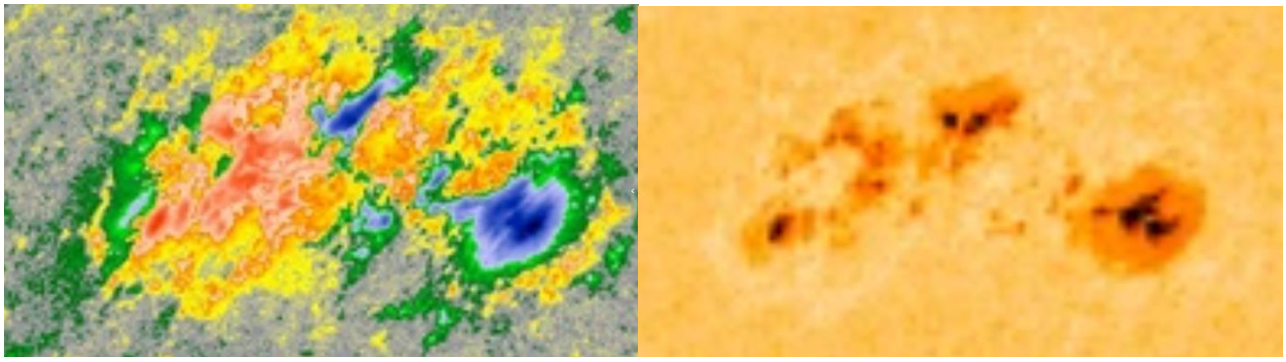
Radio Blackouts - X-Ray Flares:
Solar activity is Moderate with a couple of low level M-flares from AR3234, and is likely to remain at this level. There is a slight chance of High solar activity with any isolated X-class flaring, primarily from AR3234, but with AR3230 and AR3229 also providing a risk. None of the current facing regions are expected to leave the disc in the coming 4 days, so the flare risk has been kept flat throughout.

There are now four numbered sunspot regions on the visible disc. AR3234 (Eki/Beta-Gamma) in the northeast is the largest region, and is showing some magnetic complexity. AR3229 (Esi/Beta-Gamma) in the north centre disk is also of note, having been the source of the X2 flare on the 17th, but has faded since then. It retains some very minor magnetic complexity. The final sunspot worthy of comment is AR3230 (Dko/Beta) in the southeast, which has shown signs of trying to develop a delta region in its trailing spot. However, this trailing region now appears to be fading and breaking apart. All other spots are small or simple.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: AR3234 in the northeast, showing some magnetic complexity.



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Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at Background levels.

While there have been no notable enhancements to the high energy proton spectrum in the past UTC week, this is perhaps largely because the larger X-ray events have been limited to the eastern solar hemisphere. The westward progress of the larger regions should offer a very gradually increasing Slight Chance of reaching S1 or above as they rotate into a more favourable position, should they flare more energetically.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	15	15	20
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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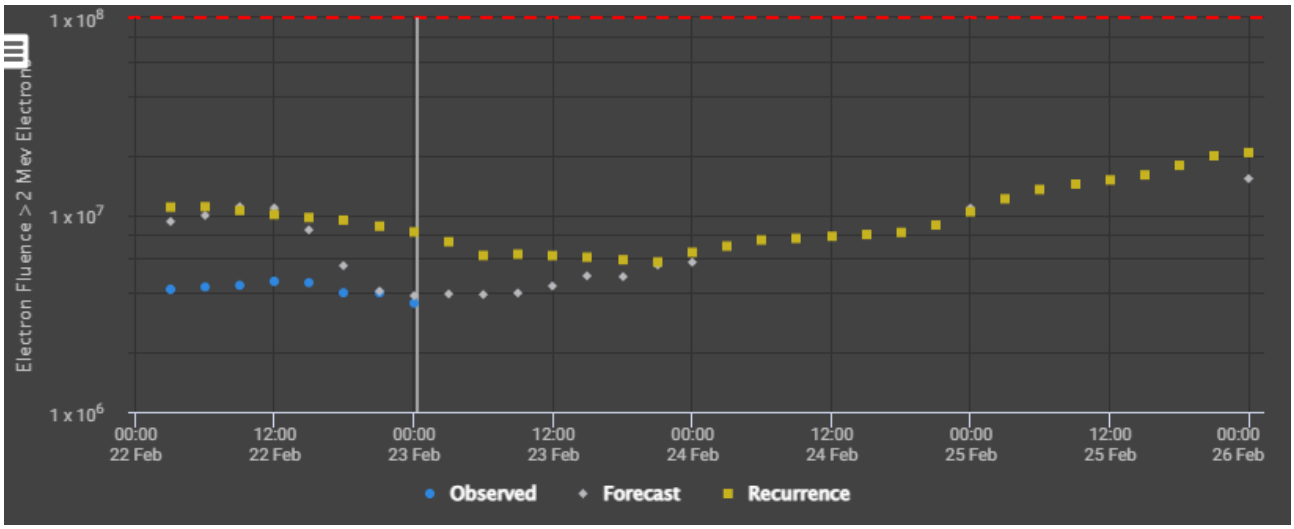
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) observed at GOES16 is now at mostly background levels. There may now be some influence in the solar wind from CH77, although it is minor, with STEREO suggesting this is likely to decline within the next 24 hours. As such, significant electron charging from this feature is considered unlikely. It is possible that a more significant HSS from CH78 may arrive on Day 3, with the timing low confidence. This may give more significant charging, but with any effects unlikely to be felt until the end of the period. This is a non-persistent feature, so recurrence is not a helpful forecasting guide here. There is the possibility of a couple of glancing CME blows on Day 1 and Day 3, but these are more likely to miss Earth.

The associated fluence is expected to remain below the Active (1e8 integrated pfu) threshold for much of the period, perhaps rising on Day 4 (26 Feb), with a slight chance of exceeding Active. MOSWOC REFM keeps a below Active trend for the next three days, which seems reasonable. With CH78 a non-persistent feature, REFM won't be taking account of this until any HSS arrives.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: MOSWOC REFM showing a below Active trend for the next three days, which seems reasonable. An increase is possible on 26th Feb, beyond the end of REFM's forecast period.



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